APPENDIX VI

NEW BEDFORD HARBOR PILOT STUDY

PRE-OPERATIONAL MONITORING - PROGRESS REPORT:

PCB Concentrations in Mytilus edulis from the July and September Mussel Deployments

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Introduction

The New Bedford Harbor Pilot Project is a cooperative effort between the U.S. Environmental Protection Agency's Environmental Research Laboratory in Narragansett, R.I. (ERLN) and the U.S. Army Corps of Engineers (COE) to evaluate a series of remedial action alternatives to clean up New Bedford Harbor (NBH). The blue mussel, Mytilus edulis, will be used throughout this study as an integrative biological monitor to measure: 1) the effects of each stage of the operation on the release and transport of contaminants, 2) biological availability of released contaminants, and 3) chronic and acute biological effects of released contaminants. The present report describes the results of the chemical analyses of mussel tissues during the first pre-operational mussel deployment. This information will be used as baseline data against which the effects of future dike construction, dredging, filling and capping operations will be compared.

Materials and Methods

Mussels were collected from a clean area in East Sandwich, Mass., returned to ERLN, and sorted according to length. A total of twenty-five mussels ranging from 5-7 cm were placed into each of 48 baskets. Custody seals were placed on all mussel baskets prior to deployment in NBH to ensure the integrity of the samples in the field. The first mussel deployment was conducted during June of 1987. Mussels were deployed 1 m above the bottom at 3 locations in NBH (Station NBH-2, Coggeshall St. Bridge; Station NBH-3, opposite the Revere Silverware factory; Station NBH-4, the Hurricane Barrier) and

at a reference station (NBH-6) in Buzzards Bay near Cleveland Ledge (Fig. 1). Each station consisted of four replicate substations with three baskets on each. A second deployment was also done during September of 1987. These mussels were deployed at the same stations except the reference station was moved from Cleveland Ledge (NBH-6) to just west of West Island (NBH-5).

For both deployments, individual baskets were retrieved from each substation on days 3, 7, and 28 and returned to ERLN with custody seals intact. On each retrieval date, subsamples of mussels from each basket were taken for organic and inorganic chemical analysis and frozen at -20° C.

Mussels from each sample were homogenized using a polytron and 2 to 5 grams of each weighed into an acetone rinsed 100 ml centrifuge tube. Octachloronaphthalene was added as an internal standard. The samples were extracted with 25 ml of acetone by polytroning the sample and acetone in the centrifuge tube for 20 seconds. The sample was centrifuged and the supernatant poured into a 500 ml separatory funnel containing 150 ml of water. This procedure was repeated two more times combining extracts in the separatory funnel. The sample in the separatory funnel was then extracted three times with 25 ml portions of freon. The extracts were combined, treated with sodium sulfate and volume reduced using a heating mantle and a Kuderna-Danish evaporator with a 3-ball Snyder column. The extract was volume reduced and solvent exchanged to about 10 ml of hexane. The sample was transferred to a concentrator tube and the volume adjusted to 10 ml. One ml was removed for lipid weight determination and the remaining 9 ml was partitioned against concentrated sulfuric acid. The sample was

then volume reduced and solvent exchanged to 1 ml of heptane using a concentrator tube and stored in a screw-top vial prior to instrumental analysis.

The samples were analyzed for PCBs by capillary gas chromatography (GC). For these analyses, 1 ul of each sample was injected splitless into a Hewlett Packard 5890 gas chromatograph equipped with a 30 m DB-5 fused silica capillary column (J + W Scientific) and an electron capture detector. Helium was used as the carrier gas at a flow rate of about 1.5 ml/min and the flow of a 95:5 mixture of argon:methane to the detector was 35 ml/min. The oven temperature was held at 60°C for 1 min and then programmed from 60 to 315°C at 10°C/min. The injector temperature was 270°C, and the detector was maintained at 325°C. Analog data from the gas chromatographs was digitized using a Perkin Elmer LCI-100 integrator interfaced to a Perkin Elmer LIMS/CLAS system. The results were stored on a Perkin Elmer LIMS systems and, after being quality assured, were shipped to the laboratory VAX computer system.

The concentrations of Aroclors 1242 and 1254, the predominant Aroclors found in New Bedford Harbor samples, were then quantified. The sum of the concentrations of these are provided as a measure of total PCBs. In addition, thirteen individual PCB congeners were quantified. These included at least one compound from each chlorination level ranging from tetrachlorobiphenyls to decachlorobiphenyl. A listing of the congeners that were quantified is provided in Table 1.

Statistical differences were determined for total PCB concentrations among stations on each collection date separately, not between collection dates, using one-way analysis of variance (ANOVA). Because of the range in values, the data were transformed (logarithm base 10) prior to analysis.

Results and Discussion

The total PCB concentrations in mussels collected during the first (July) deployment increased over time at each NBH station, with greater than an eight-fold difference between days 3 and 28 at NBH-2 (Fig. 2). In addition, PCB concentrations increased significantly ($P<0.05$) moving from NBH-4 to NBH-2 on each sampling date (Table 2). These data would indicate that PCBs accumulated rapidly in the mussels and that a gradient of exposure existed within NBH.

The mean concentrations of Aroclor 1242 and 1254 in mussels from the first deployment are presented in Table 3. These mixtures showed the same trends as seen for the total PCB levels; rapid accumulation and highest concentrations closer to upper NBH. The ratio of Aroclor 1242/Aroclor 1254 was calculated and found to be highest at NBH-2 and also increased with the duration of exposure in NBH (Fig. 3).

The concentration of 13 individual PCB congeners were also measured and are listed in Tables 4-8. Mean values were typically lowest at NBH-6 and increased moving up NBH and concentrations increased with length of exposure. The distribution of these PCB congeners in mussels at NBH-2 is graphically presented in Figure 4. In general, the lower molecular weight congeners are accumulated more rapidly and to higher levels.

The mean PCB concentrations in mussels from the September deployment are shown in Table 9. The same trends were observed for these organisms as was seen in the mussels from the July deployment. The highest concentrations were seen at NBH-2 with the levels decreasing with distance downbay. A different reference site (NBH-5) was used for the September deployment than that used in July (NBH-6). The concentrations were higher in the mussels from NBH-5 than in those deployed at NBH-6 in July.

The PCB concentrations measured in the mussels collected after 3 days of exposure were higher for the September deployment than for mussels deployed in July. This was true for those deployed at NBH-2, NBH-3 and NBH-4. The PCB concentrations in mussels collected after 7 and 28 days of exposure showed similar results for the same stations and days of exposure for the two deployments.

Table 10 reports the concentrations of Aroclor 1242 and Aroclor 1254 in the samples. As was seen in the samples from the July deployment, the ratios of Aroclor 1242 to Aroclor 1254 decreases with distance downbay. The levels of the thirteen individual PCB congeners in the samples from the second deployment are shown in Tables 11-15. The trends seen are similar to those reported for total PCBs with higher levels in the day 3 samples compared to the July day 3 samples and similar levels for the day 7 and 28 samples for the two deployments.

In summary, similar PCB concentrations were seen in mussels from both the July and September, 1987 deployments. The mussels rapidly accumulated PCBs at all of the stations within the harbor. Mussels

deployed in the northern portion of New Bedford Harbor accumulated PCBs to levels near 100 ug/g dry weight. The concentrations decreased with distance downbay. This agrees with the known distribution of PCBs in the sediments of New Bedford Harbor and with the PCB levels that we have recently measured in seawater samples from the harbor.

Table 1. Listing of the thirteen PCB congeners quantified. The naming convention used is that described by Ballschmiter and Zell (1980).

CB052	-	2,2',5,5'-PCB
CB047	-	2,2',4,4'-PCB
CB101	-	2,2',4,5,5'-PCB
CB151	-	2,2',3,5,5',6-PCB
CB118	-	2,3',4,4',5-PCB
CB153	-	2,2',4,4',5,5'-PCB
CB138	-	2,2',3,4,4',5'-PCB
CB128	-	2,2',3,3',4,4'-PCB
CB180	-	2,2',3,4,4',5,5'-PCB
CB195	-	2,2',3,3',4,4',5,6-PCB
CB194	-	2,2',3,3',4,4',5,5'-PCB
CB206	-	2,2',3,3',4,4',5,5',6-PCB
CB209	-	CL10-PCB

Table 2. Mean (standard error) total PCB concentrations (ng/g) in Mytilus edulis deployed in New Bedford Harbor during the first mussel deployment. The day 3 mean value at Station NBH-2 represents only one replicate, while all other mean values include 4 replicates. Values were transformed (logarithm base 10) prior to statistical analysis. For each collection date, means with the same letter group are not significantly different (P=0.05). The mean total PCB concentration in the Day 0 mussels collected from the reference site was 402 (22.2) ng/g.

Station	Day 3		Day 7		Day 28	
NBH-2	11800	A	45800 (5750)	A	97100 (6250)	A
NBH-3	6010 (241)	B	15800 (4240)	B	41200 (3130)	B
NBH-4	3760 (409)	C	4850 (645)	C	12600 (1430)	C
NBH-6	-- *		435 (28.9)	D	715 (76.8)	D

* - not analyzed.

Table 3. Mean (standard error) Aroclor 1242 and Aroclor 1254 concentrations (ng/g) in mussels deployed in New Bedford Harbor during the first mussel deployment. The day 3 mean value at Station NBH-2 represents only one replicate, while all other mean values include 4 replicates.

Station	Day 3		Day 7		Day 28	
	1242	1254	1242	1254	1242	1254
NBH-2	8800	3020	36300 (5690)	9460 (249)	78400 (5530)	18700 (807)
NBH-3	3810 (229)	2200 (31)	10600 (3540)	5180 (737)	28400 (2770)	12900 (397)
NBH-4	2140 (330)	1630 (93)	2290 (436)	2560 (215)	7130 (982)	5500 (492)
NBH-6	* --	* --	27.2 (6.95)	409 (25.4)	36.8 (36.8)	679 (61.1)

* - not analyzed.

Table 4. Mean (standard error, N=4) values for 13 congeners of PCBs (ng/g) in *Mytilus edulis* collected from the East Sandwich, Mass. reference station (time-zero) for the first mussel deployment.

Compound	Concentration
CB052	6.66 (0.51)
CB047	5.03 (0.40)
CB101	76.4 (14.6)
CB151	17.1 (9.37)
CB118	23.8 (1.48)
CB153	32.3 (0.97)
CB138	25.6 (0.87)
CB128	9.96 (0.21)
CB180	4.76 (0.09)
CB195	1.56 (0.08)
CB194	0.00
CB206	0.00
CB209	0.00

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB194, CB206, and CB209 were 1.86, 1.79, and 3.12 ng/g, respectively.

Table 5. Mean (standard error) values for 13 congeners of PCBs (ng/g) in Mytilus edulis retrieved from Station NBH-2 in New Bedford Harbor during the first mussel deployment. The day 3 mean values at this station represent only one replicate, while all other mean values include 4 replicates.

Compound	Day 3	Day 7	Day 28
CB052	606	1840 (221)	4720 (326)
CB047	375	1140 (126)	2940 (225)
CB101	501	1420 (104)	3530 (230)
CB151	74.8	203 (12.1)	434 (30.7)
CB118	506	1360 (79.2)	3230 (195)
CB153	276	723 (20.8)	1760 (83.8)
CB138	216	559 (16.4)	1220 (62.6)
CB128	73.6	183 (4.74)	370 (20.8)
CB180	28.4	70.2 (2.24)	87.7 (4.70)
CB195	2.49	6.49 (0.94)	6.07 (2.21)
CB194	3.37	8.36 (0.53)	0.00
CB206	0.00	3.11 (0.90)	2.41 (2.41)
CB209	0.00	6.65 (1.69)	9.88 (6.52)

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB194, CB206, and CB209 were 1.86, 1.79, and 3.12 ng/g, respectively.

Table 6. Mean (standard error, N=4) values for 13 congeners of PCBs (ng/g) in *Mytilus edulis* retrieved from Station NBH-3 in New Bedford Harbor during the first mussel deployment.

Compound	Day 3		Day 7		Day 28	
CB052	268	(14.4)	619	(169)	1700	(144)
CB047	172	(7.50)	405	(107)	1100	(89.7)
CB101	280	(10.7)	616	(129)	1790	(111)
CB151	46.3	(1.44)	96.7	(19.1)	272	(13.8)
CB118	308	(6.29)	685	(108)	1640	(71.9)
CB153	178	(10.0)	354	(55.0)	969	(39.2)
CB138	152	(3.54)	322	(36.4)	742	(24.9)
CB128	53.0	(0.86)	108	(13.4)	239	(7.08)
CB180	19.7	(0.29)	40.2	(3.94)	53.4	(2.39)
CB195	1.71	(0.04)	3.12	(0.48)	6.43	(0.15)
CB194	2.09	(0.06)	3.96	(0.44)	2.58	(0.87)
CB206	0.00		0.00	(0.21)	3.05	(0.31)
CB209	0.00		0.00		5.11	(0.47)

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB206 and CB209 were 1.79 and 3.12 ng/g, respectively.

Table 7. Mean (standard error, N=4) values for 13 congeners of PCBs (ng/g) in *Mytilus edulis* retrieved from Station NBH-4 in New Bedford Harbor during the first mussel deployment.

Compound	Day 3		Day 7		Day 28	
CB052	158	(14.5)	205	(44.5)	518	(70.6)
CB047	94.4	(8.81)	126	(27.1)	324	(46.1)
CB101	173	(13.1)	256	(44.8)	632	(79.4)
CB151	30.7	(2.09)	44.5	(7.72)	111	(13.0)
CB118	196	(13.2)	305	(38.0)	624	(68.4)
CB153	131	(7.86)	191	(27.6)	416	(44.3)
CB138	112	(5.78)	198	(26.6)	354	(36.5)
CB128	38.6	(1.84)	63.2	(7.45)	116	(12.2)
CB180	13.8	(0.59)	22.9	(2.37)	28.4	(3.55)
CB195	1.47	(0.19)	1.63	(0.08)	3.66	(0.36)
CB194	0.00		2.07	(0.17)	1.99	(0.24)
CB206	0.00		0.00		0.00	
CB209	0.00		0.00		0.00	

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB194, CB206, and CB209 were 1.86, 1.79, and 3.12 ng/g, respectively.

Table 8. Mean (standard error, N=4) values for 13 congeners of PCBs (ng/g) in *Mytilus edulis* retrieved from Station NBH-6 in New Bedford Harbor during the first mussel deployment.

Compound	Day 7		Day 28	
CB052	8.58	(0.81)	17.6	(2.63)
CB047	5.93	(0.56)	12.4	(1.50)
CB101	22.1	(1.90)	41.4	(1.47)
CB151	5.84	(0.78)	32.4	(23.2)
CB118	30.7	(2.19)	55.7	(2.47)
CB153	36.4	(3.05)	66.2	(2.31)
CB138	33.3	(3.36)	52.7	(3.60)
CB128	10.5	(0.82)	16.2	(1.52)
CB180	3.36	(0.20)	4.65	(1.05)
CB195	0.00		0.00	
CB194	0.00		0.00	
CB206	0.00		0.00	
CB209	0.00		0.00	

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB195, CB194, CB206, and CB209 were 1.44, 1.86, 1.79, and 3.12 ng/g, respectively.

Table 9. Mean (standard error) total PCB concentrations (ng/g) in Mytilus edulis deployed in New Bedford Harbor during the second mussel deployment. The day 28 mean at Station NBH-2 represents only 2 replicates, while all other mean values include 3 replicates. Values were transformed (logarithm base 10) prior to statistical analysis. Means with the same letter group are not significantly different (P>0.05). The mean total PCB concentration in the Day 0 mussels collected from the reference site was 375 (38) ng/g.

Station	Day 3		Day 7		Day 28	
NBH-2	34800	(2250) A	45600	(5400) A	89900	(22000) A
NBH-3	13300	(945) B	19400	(1190) B	41600	(1990) B
NBH-4	5720	(419) C	10200	(1720) C	15100	(1650) C
NBH-5	653	(12) D	1030	(76) D	1850	(173) D

Table 10. Mean (standard error) Aroclor 1242 and Aroclor 1254 concentrations (ng/g) in mussels deployed in New Bedford Harbor during the second mussel deployment. The Day 28 mean value at Station NBH-2 represents only two replicates, while all other mean values include 3 replicates.

Station	Day 3		Day 7		Day 28	
	1242	1254	1242	1254	1242	1254
NBH-2	26000(1870)	8810 (373)	36700(4240)	8970(1270)	61000(19800)	28700(2000)
NBH-3	9240 (656)	4063 (299)	13000(1030)	6433 (164)	24000 (2060)	17600 (491)
NBH-4	3360 (461)	2360(43.3)	5920 (848)	4300 (923)	6700 (1150)	8360 (650)
NBH-5	92.8(4.27)	560(9.61)	109(26.3)	919(50.5)	215 (28.2)	1640 (146)

Table 11. Mean (standard error, N=3) values for 13 congeners of PCBs (ng/g) in Mytilus edulis collected from the East Sandwich, Mass. reference station (time-zero) for the second mussel deployment.

Compound	Concentration
CB052	4.53 (*)
CB047	3.29 (*)
CB101	18.6 (2.27)
CB151	4.23 (0.48)
CB118	28.0 (3.16)
CB153	35.6 (3.63)
CB138	25.7 (2.63)
CB128	5.31 (0.50)
CB180	0.00
CB195	0.00
CB194	0.00
CB206	0.00
CB209	0.00

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB194, CB206, and CB209 were 1.86, 1.79, and 3.12 ng/g, respectively. (*) - only detected in one sample.

Table 12. Mean (standard error, N=3) values for 13 congeners of PCBs (ng/g) in Mytilus edulis retrieved from Station NBH-2 in New Bedford Harbor during the second mussel deployment.

Compound	Day 3		Day 7		Day 28*	
CB052	2000	(298)	2590	(302)	6130	(1700)
CB047	1260	(98.4)	1520	(182)	3760	(1000)
CB101	1790	(202)	2010	(243)	6210	(1180)
CB151	217	(22.3)	238	(26.8)	770	(123)
CB118	1680	(149)	1950	(275)	5710	(940)
CB153	866	(105)	906	(110)	3310	(310)
CB138	601	(41.7)	640	(75.4)	2190	(190)
CB128	174	(20.8)	203	(27.2)	618	(58.0)
CB180	49.7	(6.62)	51.6	(10.9)	163	(1.50)
CB195	0.00		0.00		0.00	
CB194	0.00		0.00		0.00	
CB206	0.00		0.00		0.00	
CB209	0.00		0.00		0.00	

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB194, CB206, and CB209 were 1.86, 1.79, and 3.12 ng/g, respectively. * - N=2.

Table 13. Mean (standard error, N=3) values for 13 congeners of PCBs (ng/g) in Mytilus edulis retrieved from Station NBH-3 in New Bedford Harbor during the second mussel deployment.

Compound	Day 3		Day 7		Day 28	
CB052	695	(39.3)	1110	(64.4)	2380	(148)
CB047	434	(28.1)	691	(30.1)	1580	(86.8)
CB101	714	(36.0)	1180	(60.1)	2930	(109)
CB151	100	(4.07)	167	(2.65)	420	(12.0)
CB118	811	(32.7)	1230	(64.9)	3180	(110)
CB153	358	(17.2)	614	(38.2)	1170	(60.8)
CB138	278	(19.9)	458	(5.77)	1370	(44.0)
CB128	98.7	(7.26)	155	(6.69)	427	(11.5)
CB180	24.4	(1.94)	37.8	(3.47)	103	(3.82)
CB195	0.00		3.89*		11.5*	(0.41)
CB194	0.00		0.00		7.03*	
CB206	0.00		0.00		0.00	
CB209	0.00		0.00		0.00	

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB206 and CB209 were 1.79 and 3.12 ng/g, respectively.
* - only detected in one sample.

Table 14. Mean (standard error, N=3) values for 13 congeners of PCBs (ng/g) in Mytilus edulis retrieved from Station NBH-4 in New Bedford Harbor during the second mussel deployment.

Compound	Day 3		Day 7		Day 28	
CB052	235	(23.4)	451	(95.9)	825	(130)
CB047	132	(12.3)	271	(62.6	489	(69.0)
CB101	271	(11.7)	528	(113)	1120	(132)
CB151	44.4	(0.78)	85.4	(17.8)	180	(18.4)
CB118	287	(2.40)	574	(121)	1200	(109)
CB153	183	(5.13)	341	(73.5)	808	(79.1)
CB138	163	(3.84)	296	(60.3)	693	(57.6)
CB128	59.1	(3.17)	97.2	(18.5)	212	(12.8)
CB180	14.1	(2.27)	22.6	(5.95)	46.4	(2.44)
CB195	2.72*		3.18	(0.70)	6.45*	(0.31)
CB194	0.00		0.00		3.55*	
CB206	0.00		2.69*		2.87*	
CB209	0.00		0.00		0.00	

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB194, CB206, and CB209 were 1.86, 1.79, and 3.12 ng/g, respectively. * - only detected in one sample.

Table 15. Mean (standard error, N=3) values for 13 congeners of PCBs (ng/g) in Mytilus edulis retrieved from Station NBH-6 during the second mussel deployment.

Compound	Day 3		Day 7		Day 28	
CB052	15.0	(0.22)	14.8	(3.39)	41.7	(5.31)
CB047	9.93	(0.12)	9.98	(2.22)	27.0	(3.25)
CB101	38.4	(1.48)	52.4	(5.54)	116	(11.1)
CB151	9.04	(0.45)	11.6	(0.77)	22.2	(2.41)
CB118	48.8	(2.27)	76.5	(4.78)	155	(13.0)
CB153	52.0	(1.99)	86.8	(3.59)	161	(12.6)
CB138	45.1	(2.05)	73.6	(2.87)	138	(11.5)
CB128	14.7	(1.13)	23.1	(0.64)	48.2	(3.63)
CB180	3.72	(0.20)	6.22	(0.20)	11.6	(1.22)
CB195	0.00		0.00		0.00	
CB194	0.00		0.00		0.00	
CB206	0.00		0.00		0.00	
CB209	4.57*		0.00		0.00	

A mean value of 0.00 indicates that the concentration was below instrument detection limits for that congener. The detection limits for CB195, CB194, CB206, and CB209 were 1.44, 1.86, 1.79, and 3.12 ng/g, respectively. * - only detected in one sample.

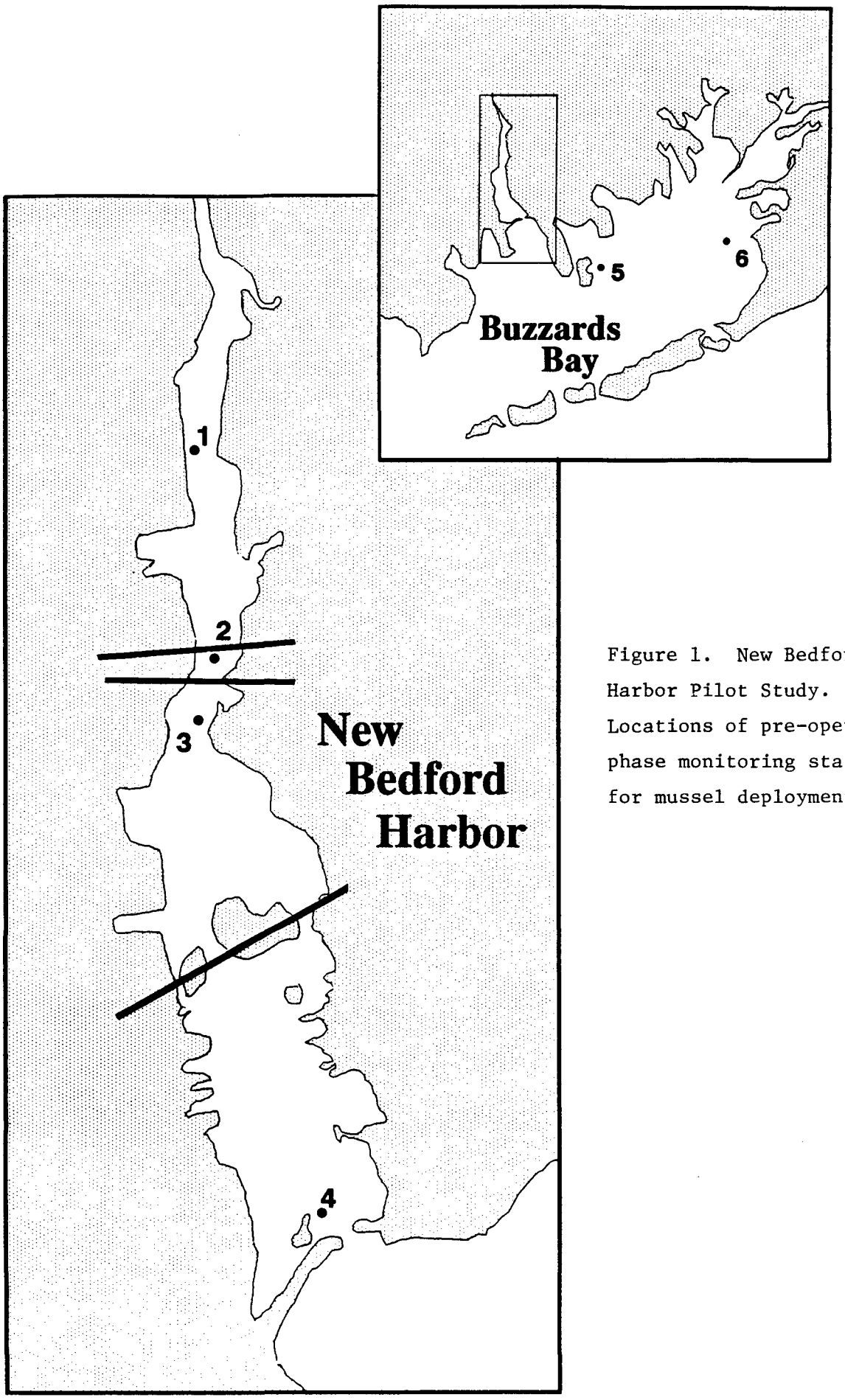

Figure 1. New Bedford Harbor Pilot Study. Locations of pre-operational phase monitoring stations for mussel deployments.

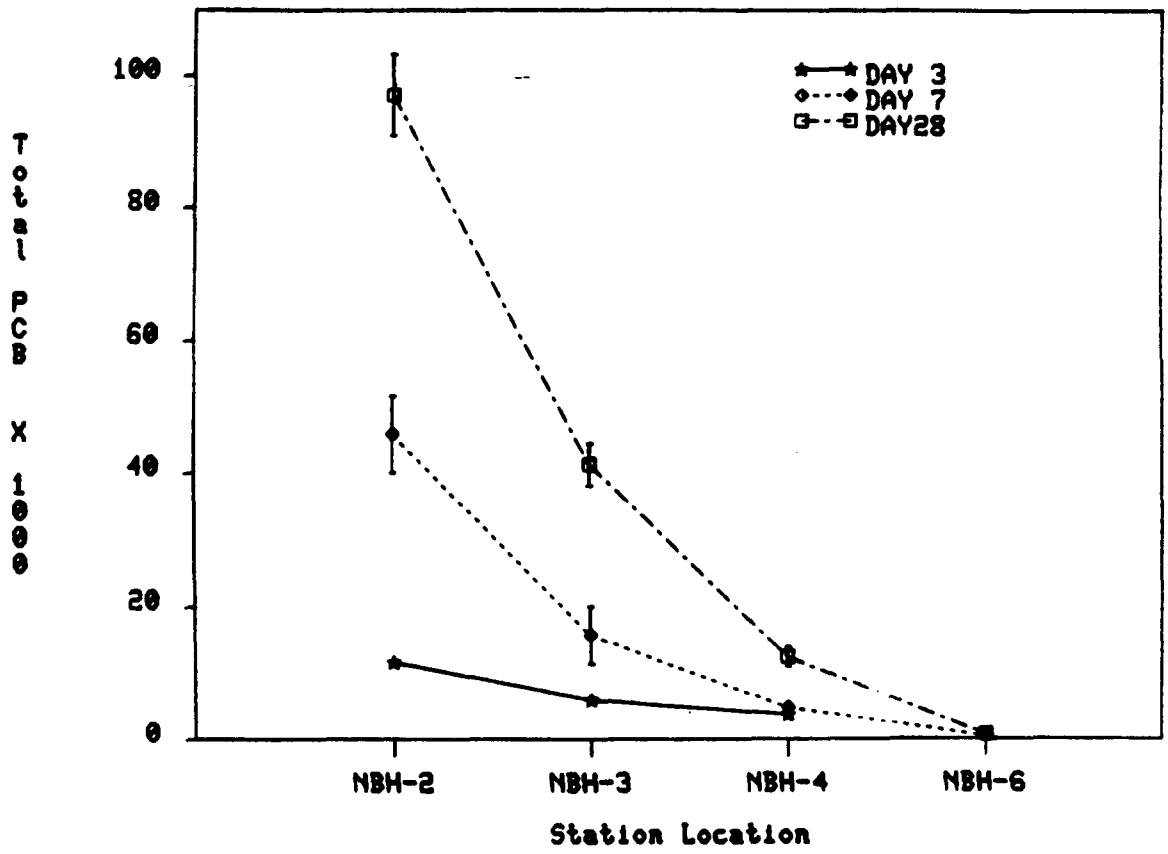

Figure 2. The mean (± standard error) total PCB concentrations (ng/g) in mussels collected during the first preoperational deployment.

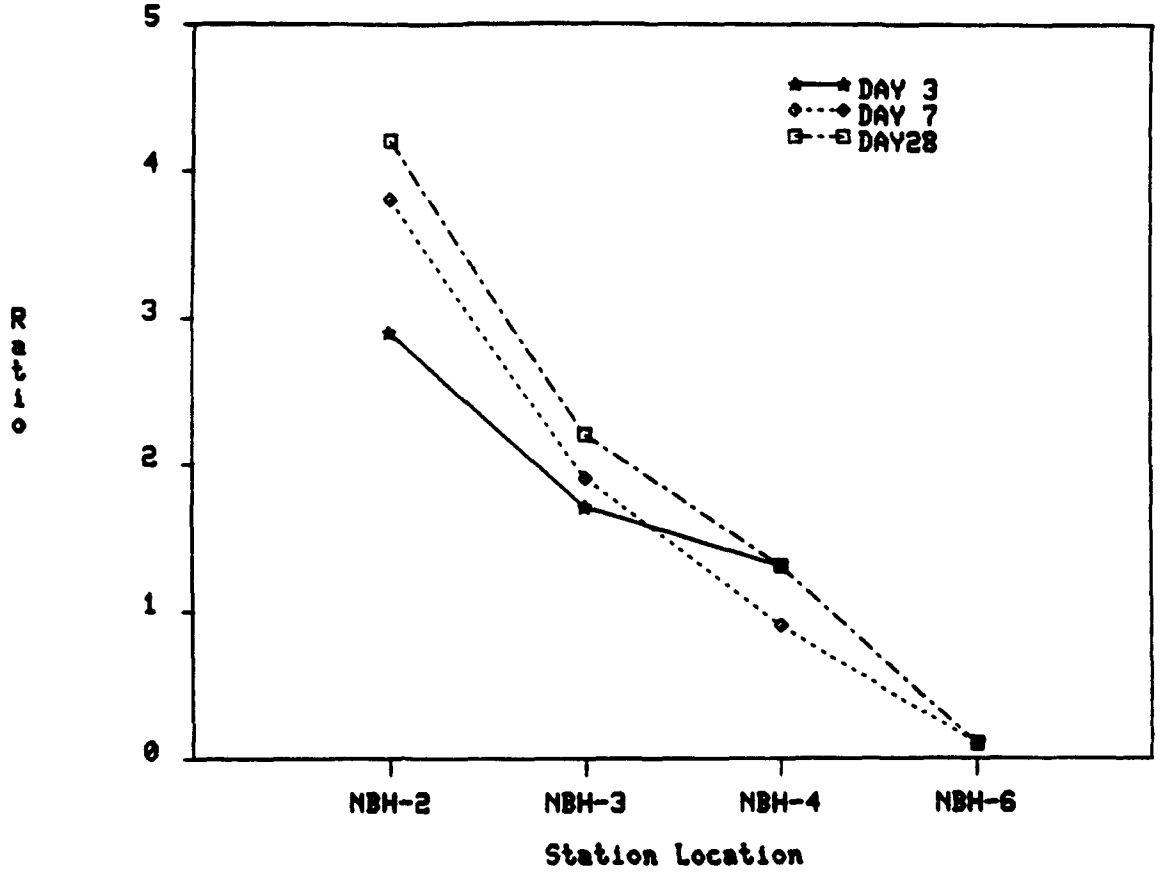

Figure 3. The ratio of Aroclor 1242/Aroclor 1254 in mussels after 3, 7, and 28-day exposures in New Bedford Harbor during the first preoperational deployment.

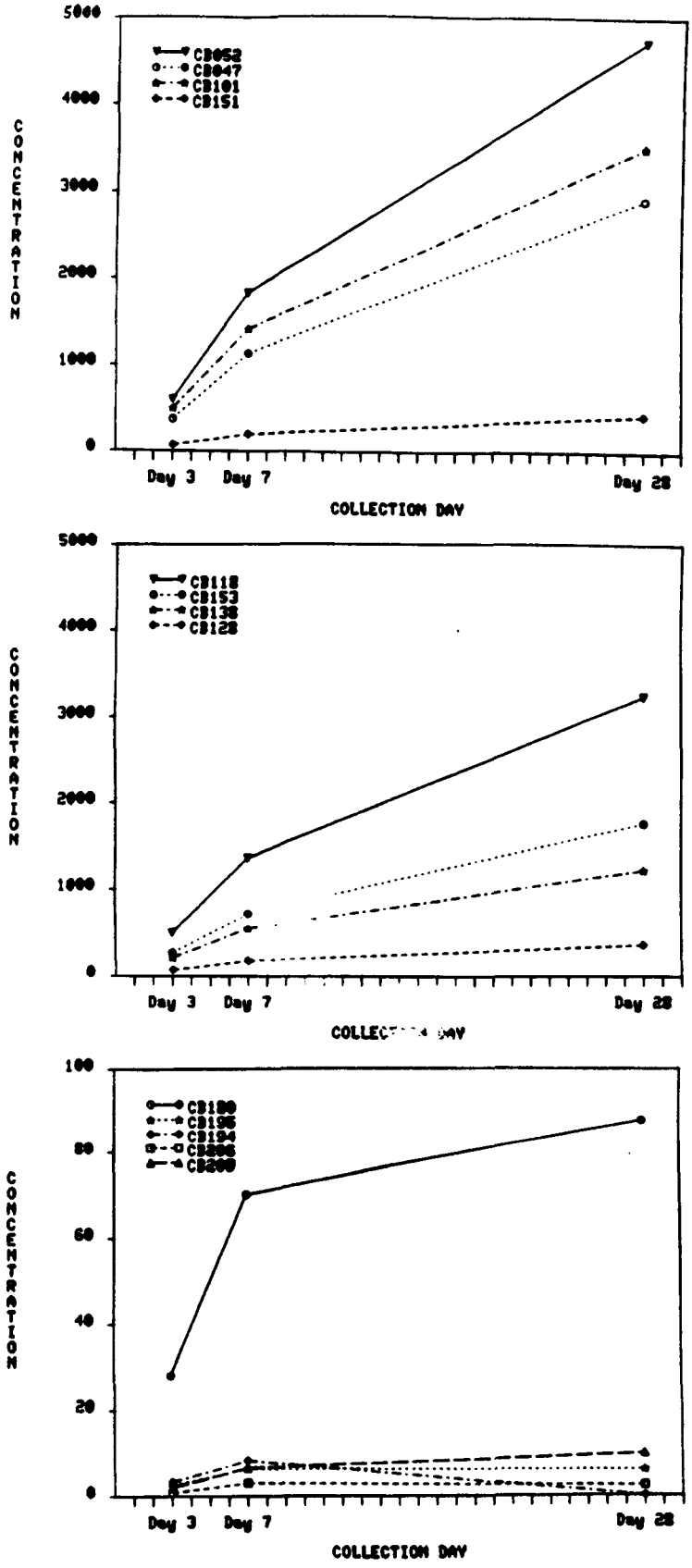

Figure 4. The concentrations of PCB congeners in mussels collected from Station NBH-2 in New Bedford Harbor after 3, 7, and 28-day exposures during the first preoperational deployment.